

## Review

## Discourse on pulse in medieval Persia—the Hidayat of Al-Akhawayni (?–983AD)

Kazem Khodadoust<sup>a</sup>, Mohammadreza Ardalan<sup>b,\*</sup>, Kamyar Ghabili<sup>a,c</sup>,  
Samad E.J. Golzari<sup>d,e</sup>, Garabed Eknayan<sup>f</sup>

<sup>a</sup> Tuberculosis and Lung Disease Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

<sup>b</sup> Chronic Kidney Disease Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

<sup>c</sup> Young Researchers Club, Tabriz Branch, Islamic Azad University, Tabriz, Iran

<sup>d</sup> Medical Philosophy and History Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

<sup>e</sup> Students' Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran

<sup>f</sup> Renal Section, Department of Medicine, Baylor College of Medicine, Houston, TX, USA

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## ABSTRACT

In a period of compilation, original observations and expansion (900–1100 AD), Persians described new clinical manifestations of the diseases and expanded the earlier knowledge of materia medica. In the epoch of the Arabic language domination in the scientific literature of this period, advent of medical authors to write in Farsi shined in the Persian principalities. Akhawayni Bokhari was by far the most outstanding scholar of the time who wrote one of the earliest pandects of medicine of the period, the *Hidayat al-Mutallimin fi al-Tibb* (Learner's Guide to Medicine) in new Persian. The *Hidayat* is a relatively short and simplified digest of medicine at the time providing a glimpse of high level of medical education at the Samanid period (819–999). The present article is a translation of the sections of the *Hidayat* related to the pulse and its characters and conditions affecting the pulse in an attempt to increase our knowledge of the medicine, and particularly the pulse examination throughout the medieval era.

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## 1. Introduction

The flourishing of the sciences in the Near East, i.e. Islamic Golden Age, stands in sharp contrast to their ruinous decline in the West during the medieval era [1]. During the Middle Ages in Baghdad, scholars of different religions such as Muslim, Christian or Jewish contributed to the development of the Islamic medicine, later influencing the rise of European science during the Renaissance [2]. Thanks to the translation and assimilation period (ca. 750–900), the Samanid dynasty (819–999) was concurrent with the advent of renowned scholars, Muhammad ibn Zakariya al-Razi or Rhazes (ca. 865–925), Ali ibn al-Abbas al-Majusi or Haly Abbas (930–994), and Abu-Ali al-Husain ibn Abdollah ibn Sina or Avicenna (981–1037) [1]. These polymaths were not only responsible for accumulating all the existing information on medicine of the time, but adding to this knowledge by their own perceptive observations, trials and skills. In other words, two major phases accompanied the evolution of the sciences during this period: a period of translation and assimilation, and a second of compilation, original observations and expansion (900–1100 AD). Although Christians mostly dominated the first period, Persians had ascendancy over the second phase of innovation, commentary and systematization, thereby forming descriptions of new clinical manifestations of the diseases and expanding the earlier knowledge of materia medica [1].

In the era of Arabic language domination in the scientific literature, Hakim Maysari, Abu Mansur Muvaffak Harawi, and Akhawayni Bokhari were first three authors who wrote their treatises in Persian. Hakim Maysari composed medical poems (*Danishanameh*) in 980. Harawi compiled the *Book of the Remedies* (*Kitab al-Abnyia an Haqaiq al-Adwiya*) between 968 and 977. Undoubtedly, the most significant work of the three was that of Akhawayni Bokhari, the *Hidayat* [2–4]. Akhawayni Bokhari, Abubakr Rabi ibn Ahmad, worked and lived in Bukhara most likely all his life, a city currently at the Republic of Uzbekistan located along the Silk Road. Bukhara prospered during the Samanid era, when it became one of the intellectual canters of the Islamic world, and Avicenna resided there for a period of time. Yet little is known about the life of Akhawayni; it is not precisely known when he lived [5]. However, Mojtaba Minovi, a contemporary Iranian historian, has estimated that Akhawayni has written his prominent book, *Hidayat al-Mutaallem*, before 983–984 AD [6]. Akhawayni was the student of Abu al-Qasem Maqanei Razi, who himself studied under Abubakr Muhammad ibn Zakariya Razi, Rhazes [7]. Although Akhawayni has collected all his twenty-year medical experiences in the *Hidayat*, three of his monographs on the pulse (*Kitab al-Nabz*), on the anatomy (*Kitab al-Tashrih*), and on material medica (*Qarabadin*) have been indicated in the *Hidayat* as well. These three manuscripts have not survived [8]. Throughout his clinical experience, Akhawayni tested the views of his predecessors, among which are Galen, Hippocrates, Rhazes, Yahya ibn Sarafyun, and only occasionally Dioscurides, Archigenes together with Aristoteles, with his own experiments [1,5]. While he indicates others' errors several

\* Corresponding author. Tel./fax: +98 9141168518.  
E-mail address: [ardalan34@yahoo.com](mailto:ardalan34@yahoo.com) (M. Ardalan).

times, he also freely declares when his own experimental treatments end in failure. Akhawayni was also greatly experienced in treating melancholy; hence he is known as the “physician for the insane” [7].

Hidayat al-Mutaallemin fi al-Tibb (Learner's Guide to Medicine), the oldest extant treatise on medicine written in new Persian, is Akhawayni's only existent book and sole source of information about him. The Hidayat is a relatively short and simplified digest of medicine at the time providing a glimpse of high level of medical education at the Samanid period. Although dedication of the books such as Hakim Maysari's Danishnameh to powerful rulers or wealthy patrons was the custom of the times [9], Akhawayni dedicated the Hidayat to his son and to other students of medicine. Akhawayni indicates that he has written his book in a “light and simple” style to help beginners [7]. Some years after the death of Akhawayni, three known manuscripts of the Hidayat were copied. The oldest one, copied in 1058, is the manuscript in the Bodleian Library, Oxford (Figs. 1 and 2). This copy belonged to the Prince Farhad Mirza Motamed al-Dowleh, the son of Abbas Mirza (a Qajar crown prince of Persia in 1799). The second (dated 1100) and third (copied sometime in the 11th century) copies are in the Fatih Library of Istanbul and the Iranian National Library of Malek in Tehran, respectively [6,7]. Dr. Jalal Matini, a contemporary Persian writer, compared the three existent manuscripts and published a literary edition of the Hidayat in 1965 [7].

Although more famous medical books (e.g. Avicenna's The Canon of Medicine and Jorjani's Treasure of King Khwarazm) succeeded the Hidayat, it did not become obsolete in subsequent centuries [10–12]. The fact that its extant manuscripts were copied, a century after it was first written, can be construed as an indication of its widespread use and immense influence on the medicine of its time [1,13]. Nizami Aruzi, a Persian poet and prose writer in 12th century, in his Four Discourses (Chahar Maqala) recommends the Hidayat to the medical students as one of the “intermediate works” that every physician should study carefully under a professor's guidance [14].

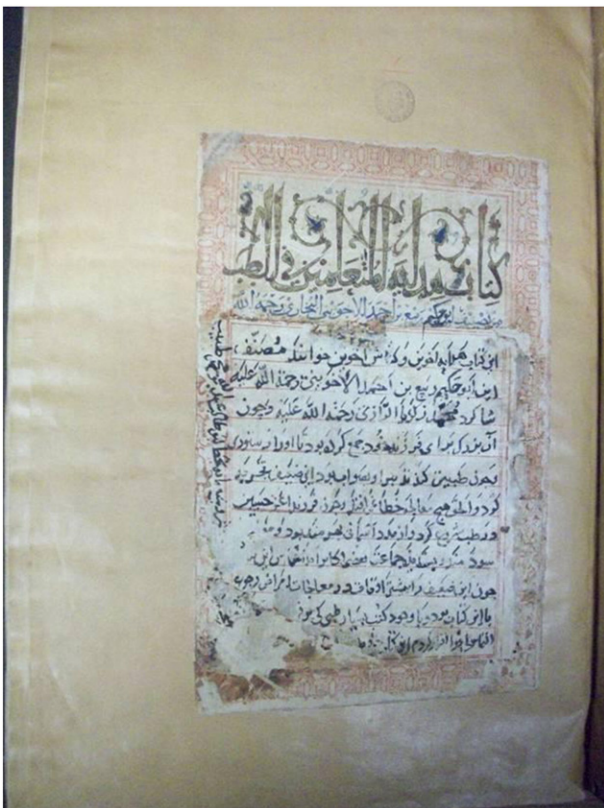


Fig. 1. The frontispiece of Hidayat (Bodleian version). Reproduced with permission from Middle Eastern & Islamic Manuscripts, Bodleian Library, Oxford.



Fig. 2. The colophon of Hidayat (Bodleian version). Reproduced with permission from Middle Eastern & Islamic Manuscripts, Bodleian Library, Oxford.

The Hidayat is divided into three major parts and two hundred chapters (Bab) possibly edited by Akhawayni's son. The first part, including 51 chapters, provides general information on the four basic humors (akhlat), on the functions of bones, nerves, muscles, and blood vessels, and discusses the principle organs, from brain to bladder and sexual organs; it continues with traditional topics of the human “faculties” and “pneumata” (qowa, arwah), the causes and symptoms of illnesses, and the six “non-naturals”: the air around us; climates and epidemics; food and drink; movement, rest and gymnastics; sleep and waking; retention and excretion. The second part (130 chapters) describes and discusses a long list of localized diseases, roughly a capite ad calcem, as well as other topics such as wounds, poisons, etc. The third part provides information on fevers, urine, hygiene and pulse in 19 chapters [5]. The latter consists of two chapters on “The Pulse and its Characters” and “A Discourse on the Factors Related to the Pulse”. What follows is a translation of the chapters related to the pulse and its characters and conditions affecting the pulse in an attempt to increase our knowledge of the medicine, and particularly the pulse examination throughout the medieval era.

## 2. Main characters of the pulse

...and this movement [pulse] has three dimensions: length, width and depth. When this moving object [pulse], [that is] along the forearm, is lengthened more than usual, it is named elongated [pulse]. When it is widened more than usual it is named wide pulse, and when it is higher than usual; it is named elevated pulse. When the pulse appears under the fingers more than usual in all three dimensions, it is named Pulsus Magnus.

...quick expansion is named Pulsus Celer. Sluggish completion of expansion is named Pulsus Tardus and moderate velocity of expansion is named moderate between Pulsus Celer and Pulsus Tardus. An expansion radiating from the center toward the margins of the heart and arteries is named Inward–Outward movement. A constriction commencing from the margins of heart and arteries toward the center of the heart and arteries is named Outward–Inward movement. Therefore, two pauses separate two movements. The pause between expansion and constriction is named External Pause and the pause between constriction and expansion is named Internal Pause. Prolonged Internal Pause is named Pulsus Rarus and shortened Internal Pause is named Pulsus Frequens... and these four time sequences altogether form a cycle. Briefly, from one expansion to another expansion is considered one cycle.

...when artery moving under your finger is hard resembling a bowstring, it is named Pulsus Durus, and when it is soft resembling an air-inflated sheep gut, it is named Pulsus Mollis... [Pulse] resembling a full bowel (intestine) is named Pulsus Plenus (engorged pulse) and when resembling an empty bowel (intestine) under the finger, it is named Pulsus Vacuus (empty pulse) ... when pressing fingers cannot stop the pulse easily, it is named Pulsus Fortis (strong pulse), and when it stops with a small pressure it is considered Pulsus Friabilis (weak pulse)...

...so far I have explained six characters for the pulse; firstly based on the amount of expansion, secondly movement of the pulse, thirdly amounts of the pause [between the pulses], fourthly degree of hardness and softness in vessels, fifthly the amount of vessels contents and sixthly the motion power of the arteries...

...when pulses are different in all their characters, they are named completely different (unequal) pulses. When they are different only in one character, it is named different regarding that character and equal in other characters. When a different (unequal) character or pattern happens repeatedly [after a constant number of cycles], it is named Variable-Regular Pulse...which occurs in each tenth [cycle] in a repetitive pattern...

...on the other hand if the pulse is different (unequal); once in fourth, another time in fifth or sixth or seventh or any cycle from cycles ...and keeps this irregular pattern for three or four consequent times more or less, it is named Irregular-with-Round [Pulse] ... while regularity is better than irregularity, Irregular-with-Round is better than [Irregular] without-Round [Pulse]...

...each pulse [movement] has four time components. First one is Expansion Time, another is Contraction Time, third one is the Time of External Pause, and the fourth is the Time of Internal Pause. Every physician should measure and compare these time components [in different pulse cycles] with each other; movement time with movement time, and pause time with pause time... and this character is called the meter [of the pulse]... a child's pulse is different from a young adult's pulse, and the young adult's pulse is different from a middle-age or elderly person's pulse... when the pulse of a child resembles the pulse of an adult or when the pulse of an adult resembles the pulse of a child, it is named an Undesired Pulse. A pulse that is not compatible with those pulses mentioned earlier; the child's, the young adult's, the middle-aged or elderly person's pulse, is named an Inconsistent-with-Meter Pulse (Arrhythmic Pulse)...

...and the tenth character [of the pulse] is a person who examines a patient's artery recognizes the serious diseases... when the artery under the [examiner's] hand is warmer than other parts [of the body], it means that the disease is serious...

It was known to the medieval physicians that pulse cycles were reflections of cardiac cycles [15]. This relationship has been probably adopted from the ancient Egyptian medicine [16–18], as later Herophilus (335–280 BC), Rufus of Ephesus (1st–2nd century AD) and Galen (129–200 AD) noted that the heart was the cause of arterial pulse [19]. On the other hand, Akhawayni's belief that arteries are filled with blood and pneuma (air) is a Galenic concept thought to have originated from the ancient Egyptian physicians [16,20]. Following ancient Greek physicians, Akhawayni believed in four different movements in an arterial pulse: two movements and two pauses after each movement. The similar description of the arterial pulse components is depicted in both Rhazes's and Avicenna's books [21–23]. In addition, ancient Chinese and Greek physicians including Galen erroneously believed that there was a unique type of pulse for every organ of the body and for every disease [24]. Although Akhawayni and his successors used pulse sensation as prognostic and diagnostic factor and for diseases differentiation, they have not defined any particular pulse for every organ and disease [25]. This may imply a gradual transition from the ancient Chinese and Greek medicine to the modern medicine through the experiments of the medieval scholars.

In all first six characters of the pulse described by Akhawayni, there are two extremes (e.g. Pulsus Celer and Pulsus Tardus) and a medium condition considered as normal. This simple triple classification applies to all those characters, and various complex compounds are emerged from combination of simple ones. Pulse varieties (superficial, deep, slow, quick) were first portrayed in an ancient Chinese medical book, Nei Ching (The Yellow Emperor's Classic of Internal Medicine) which may have been written about the end of Chou dynasty (249 BC) and consists of dialogs between the Yellow Emperor, Huang Ti (2698–2598 BC), and his wise minister and physician, Ch'i Po [20,26,27]. Apart from the four principal varieties of the pulse, the ancient Chinese medicine considers numerous subsidiary varieties such as slippery, small, empty, long, soft, irregular, and many others [27].

Later, in his treatise on pulse, Archigenes (1st century AD) counted ten varieties of pulse based on the rhythm, power, time, fullness, regularity, etc. [19]. However, the so-called triple classification of pulse by Akhawayni, i.e. two extremes and a medium condition, was earlier used by Galen [19]. A similar pulse classification has been used in later years by Avicenna [21,28].

Furthermore, Akhawayni indicated consistency or inconsistency between various characters and regularity or irregularity of the pulse as seventh and eighth characters of the pulse. A clear description of rhythm and better prognostic value of the regular-irregular rhythm compared with the irregular-irregular rhythm has been mentioned in the Hidayat. This classification is similar to what is currently known of the arterial pulse characteristics in arrhythmias such as atrial fibrillation [15]. The subject of regularity/irregularity of the pulse dates back to the pulse-lore of the ancient Hindu physicians [19]. Likewise, the ancient Greek sphygmologists, Herophilus, Archigenes, Rufus of Ephesus and in particular Galen, highlighted the concept of regularity/irregularity in their treatises on the pulse [19].

Rhazes first introduced the ninth and tenth characters of the pulse as the meter (harmony) of the pulse and the temperature of the pulse (hotness or coldness), respectively [23]. Although these additional characters of the pulse were neglected by the ancient Greek physicians, Rhazes's successors (Akhawayni and Avicenna) have discoursed on these features [7,21,25]. In his Hidayat, Akhawayni defines the ninth character of the pulse as the compatibility of the pulse with age. Accordingly, the pulse is isorhythmic when compatible with the patient's age. When the child's pulse is similar to the elderly person's pulse, it is pararhythmic or heterorhythmic (Undesired Pulse), and vice versa. Arrhythmia is also a condition in which the rhythm is absolutely abnormal; it does not correspond to the rhythm of any age. Regarding the tenth character of the pulse (hotness/coldness of the pulse), Akhawayni believes that the hot pulse is observed in patients with hectic fever, emaciation fever, and even prior to syncope (falling). The causes of the hot pulse were earlier indicated by Rhazes [23]. According to such categorization of the pulse, Akhawayni describes more than fifty pulses with definite nominations and numerous complex combinations. Altogether, what Akhawayni composed on pulsology in his Hidayat is more thorough than his ancestors; it detailed causes of the different pulses and comprehensive classification of the pulse.

### 3. Conditions affecting the pulse

...you should know that conditions affecting the pulse are presented in three types. One is natural [conditions] including pulse of the children, young adults, middle-aged, and elderly persons, pulse of females and males, and pulse in summer, winter, spring... other [conditions] are non-natural, such as; pulse of overweight [persons], slims, [pulse] in hunger or [pulse] after eating, [pulse] in tired [people] and pulse of people after taking bath. Third [condition] is named unnatural [conditions] such as pulse of sick persons...

Akhawayni emphasizes on the effects of various natural conditions (climate, food, drink, age, exercise, pregnancy, sleep and waking state, pain, temperament, and numerous emotional states such as anger, pleasure, joy, grief and fear) on the pulse. The relationship between the natural conditions and the pulse was first established by the ancient Chinese physicians. They not only considered the aforementioned natural circumstances, but also valued the influence of stars on the pulse [19,27]. The latter might reveal that the ancient Chinese pulse-lore was chiefly on a traditional, rather than an experimental, basis [26]. On the other hand, Galen believed in all the three conditions affecting the pulse as described by Akhawayni (natural, non-natural and unnatural conditions) [19,29]. Meanwhile, in his *Hidayat*, Akhawayni has not pointed to detection of both pregnancy and sex of an unborn child through the pulse examination, an interesting method first applied by the ancient Chinese physicians and later by Avicenna [19,27,30].

#### 4. Specific nominations of the pulse

...Pulsus Decurtate (Pulsus Myurus) is different (unequal) regarding the amount of Expansion; a big pulse is followed by a little pulse, whereas third pulse is smaller than the previous ones and consequently the pulses become smaller and smaller until there is not any [pulse] to decrease...and once more the pulse becomes bigger and bigger and gradually gains its first magnitude, more or less... this is named Constant Decurtate observed in hectic fever... and in wavy pulse (Pulsus Fluctuosus) the pulse is palpated wide and soft under the finger, one [pulse] is bigger and taller (Pulsus Elevatus) and another [pulse] is deeper (Pulsus Profundus) resembling the waves of the sea... Pulsus Vermicularis is similar in appearance to Pulsus Fluctuosus; it is however not as wide and tall as Pulsus Fluctuosus... Although Pulsus Vermicularis could convert into Pulsus Fluctuosus, it seems impossible for Pulsus Formicans to reconvert into Pulsus Serratus, and [Pulsus Formicans] is fatal... In Serrated Pulse (Pulsus Serratus), some [pulses] are taller and some [pulses] are smaller resembling saw-teeth... While being similar to Pulsus Serratus, Pulsus Formicans initiates as Pulsus Formicans, and it is named formicans (ant-like) due to its small and frequent nature, and resembling the pulse of infants... Pulsus Serratus is produced because of warm phlegm on the diaphragm or in the lung, and transformation of Pulsus Serratus to Pulsus Formicans is a sign of deteriorating weakness and approximation of death...

Pulsus Decurtate (Pulsus Myurus) and Pulsus Fluctuosus are probably different descriptions of what is currently known as “pulsus alternans” happening secondary to weakened myocardium [15]. Likewise, Rufus of Ephesus and Galen described Pulsus Myurus as a pulse with a diminishing strength tapering off like a “rat tail”. This type of pulse has been suggested as sinus arrhythmia in a historical review of the pulse [19].

The earliest description of ventricular fibrillation probably belongs to the ancient Egyptians. According to a treatise on the heart and circulation in the Ebers papyrus (1500 or 3500 BC), trembling of the heart and lack of the vessels pulsation leading from the heart seem to be characteristic of ventricular fibrillation [16,17,31]. Although Pulsus Serratus and Pulsus Formicans were earlier disclosed by Rufus of Ephesus, Galen and Rhazes, Akhawayni's description of an irreversible transformation of Pulsus Serratus to Pulsus Formicans is unique. This is probably an early description of transformation of ventricular tachycardia into ventricular fibrillation; he states that the reverse transformation is impossible and the rhythm is fatal. It is believed that deterioration of the ventricular tachycardia into the ventricular fibrillation was first suspected in 1921 [32,33].

...Pulsus Dorcadissans (Deer Leap Pulse or Pulsus Gazellans or Jerking Pulse) is a pulse that hits the hand at its [first] Expansion

and then hits the hand with a second Expansion, while the first hit is smaller than the second. Pulsus Duplex (Dicrotic Pulse) is similar [to Pulsus Dorcadissans]... the one denoting the amount of Expansion is named Dorcadissans, while the other representing the power of Expansion is named Pulsus Duplex...

...Deliquesce Pulse (Dissolved Pulse, Reaped Pulse) happens as a result of a decrease in power and if you would find silence when you expect a movement, that is called Pulsus Intercidens (Intermittent Pulse)... and in another type you would find movement when you expect a silence and it is named [Pulse] occurring in the middle (Pulsus Cadens in Modio, Supernumerary Pulse)...

Pulsus Dorcadissans had been earlier described by Herophilus, and later by Galen, as the “leap of a goat”, or “Pulsus Caprizans” [33,34]. Bedford declares that the historical descriptions of Pulsus Dorcadissans and Pulsus Duplex have been more comprehensible since Joseph Struthius (1510–1568) graphically illustrated these two terms in his *Ars Sphygmica* [19,35]. Pulsus Dorcadissans might be suggestive of Pulsus Bisferiens, a twice-beat pulse that Galen believed that was characterized by “quies media ictus” (a central pause in the stroke) [36]. In modern medicine, the bisferiens pulse is characteristic of mixed aortic valve disease or of hypertrophic cardiomyopathy with obstruction. The former best matches the historical description of the Pulsus Bisferiens [36]. Pulsus Duplex or Dicrotic Pulse was first used by the pre-Galenic physician, Rufus of Ephesus [19].

Perhaps Akhawayni deems the Deliquesce Pulse (Dissolved Pulse, Reaped Pulse) as extrasystole, a term corresponding to the intermittent pulse in the works of Galen and Rhazes [19,23]. Interestingly, the ancient Egyptian physicians seem to have been able to detect abnormalities of the heartbeat; extrasystoles were called “forgotten beats” [20].

...in Pulsus Tremulus, the artery vibrates resembling the string of a musical instrument being vibrated by a music minstrel... and Pulsus Tremulus is generated by a large phlegm or mass in the cardiac area preventing the Expansion. When the condition deteriorates, another pulse named Pulsus Retortus (Wiry Pulse) appears leading to death...

Akhawayni described a cause-and-effect relation between a collection in the cardiac area preventing the heart expansion and appearance of a certain type of pulse. It is unclear whether the above passage represents ventricular tachycardia and fibrillation happening during heart failure or it is one of the earliest descriptions of pulsus paradoxus appearing during cardiac tamponade. In his *Al-Mansuri fi al-Tibb* (Liber Al Mansoori), Rhazes has stated such a relationship [23]. However, the pathophysiologic connection between pericardial collection and appearance of a new type of pulse is interesting [34,37]. Knowledge of the pericardium dates back to the time of Hippocrates (ca. 460–370 BC), and pericardial effusion was observed by Galen [38]. Cardiac tamponade is a clinical syndrome caused by the accumulation of fluid in the pericardial space resulting in reduced ventricular expansion and filling and consequently leading to subsequent hemodynamic compromise. Since antiquity, wounds of the heart had been considered immediately fatal, until Paré observed a delayed death after a stab to the heart in the 16th century [37]. The physiology of cardiac tamponade was then elucidated in 1669 by the Cornish physician Richard Lower. Akhawayni's description is very similar to the pathophysiologic mechanism of cardiac tamponade described by Richard Lower [37].

#### 5. Discussion

Akhawayni has made a great attempt to thoroughly cover the subject of pulse in the *Hidayat*. He believes that longtime experience and knowledge are required to completely master in this field. In the meantime he tries to make a semiotic analysis and discussion of both diagnostic and prognostic values for different kinds of pulse. He frequently illustrates an abstract concept by analogy with something concrete. In different

conditions the characters of pulse have been described through comparing them with familiar situations and activities [10]. By the time Akhawayni wrote the Hidayat, the translation phase of medicine was almost over and Greek medicine was widely accepted in medicine of the period [1]. Galenic doctrine in pulse, in spite of being modified and improved by Rhazes and his successors, was the main stream of thought in this field [39]. Akhawayni mentions his own experience in the practice of medicine throughout which he claims to have tested the teachings of his predecessors with his own investigations and does emphasize on more logical and effective ones [10]. According to his writings, it could be assumed that he probably had access to the writings of Rhazes and other translated classics. The most quoted author mentioned by Akhawayni is Galen, followed by Hippocrates, and Rhazes [1].

Being an inclusive, practical and condensed compendium, the Hidayat of Akhawayni is a synopsis version of medical knowledge fading in comparison to the encyclopedic content of the Canon of Avicenna and Continens of Razes [1]. Nonetheless, Akhawayni's chapter on pulse is presented in much more comprehensive way than the same subject by Avicenna and Rhazes.

The specific and unique feature of the Hidayat of Akhawayni and its comprehensive discourse on the pulse does not lie in its content, but rather in its originality of insights into the medical education. There are many repeated sentences and pieces of advice in the text, and it seems one would observe a live conversation between the master and student(s). It would be logical and fair to consider the value of the Hidayat of Akhawayni as the first inclusive medical pandect in Persian that helped the expansion of the knowledge of medicine in Persia and middle-Asia in the medieval era. Categorizing the arterial pulse more thoroughly than his predecessors, Akhawayni seems to be abundantly expert in this field, and as he mentions he also had a special book on the subject of pulse [10].

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